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(PLATES 3 AND 4)

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THE SUSCEPTIBILITY OF SOME POTATO VARIETIES TO COMMON SCAB (*ACTINOMYCES SCABIES* THAXT. GUSSOW) IN DIFFERENT SOILS.

By

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Plates 3 and 4.

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Introduction.

Scab, Potato Scab, Common Scab, Ordinary Scab, and Brown Scab, are all designations applied to what is the most common malady affecting potatoes, this scab being known wherever the crop is cultivated. It may be noted, that following the proposal made in 1914 by Lutman and Cunningham (10) the name " Corky Scab " is occasionally used for the disease by American workers, Heald (6), Owens (14). The name " Corky Scab," however, was first suggested by Johnson (7) in 1908 for an entirely different disease of potatoes, viz., that caused by *Spongospora subterranea* Wallr. Although in a subsequent paper Johnson (8) states that he preferred the term " powdery " to " corky," the latter came into more or less general use amongst plant pathologists in Great Britain and Ireland. The name Corky Scab is still used by writers in these islands, but always with reference to the disease caused by *Spongospora subterranea,* and not in the sense it is applied in America.

Common Scab can assume a variety of forms, ranging through all gradations from deep depressions penetrating half a centimetre into the flesh of the tuber (" Pitted Scab "), to wart-like outgrowths raised 2-3 mm. above the tuber surface (" Stud " and " Tumulus Scab "). Both the sunken and the raised type may may occur on the same potato, and the scab spots may be few or numerous: in some cases the entire surface of the tuber is covered with excrescences.

Scab does not appear to affect detrimentally the culinary qualities of the potato; indeed in this country many people believe the contrary, *i.e.* that scabby potatoes are generally of good quality. Scab, however, is definitely injurious in the following ways:

(i) Scabby tubers are unsightly, and this appearance detracts from their market value.

(ii) Deep peeling of badly affected tubers is necessary previous to cooking, thus leading to considerable waste.

(iii) During storage, and particularly under dry conditions, scabbed tubers lose more moisture than clean tubers; this leads to some shrinkage and loss in weight.

(iv) Scab lesions facilitate the entry of secondary organisms which cause rot. In wet years this is especially true of the blight fungus (*Phytophthora infestans*).

(v) Badly scabbed tubers are totally unsuited for seed purposes. Apart from spreading the disease, the eyes of such tubers are often weak, and fail to produce sturdy sprouts.

Cause of Scab.

Common Scab of potatoes is caused by species of *Actinomyces*. These are organisms of a type intermediate between bacteria and fungi: formerly classified as bacteria, they are now included in the fungi. The genus *Actinomyces* is a large one, and most of the strains capable of causing potato scab seem to be normal soil inhabitants. Although scab is generally attributed to *Actinomyces scabies* Thaxt. Güssow, numerous strains (or species) of the organism exist. Millard and Burr (13) identified 24 separate strains: some of these differed considerably in pure culture, and varied greatly in their virulence and in the type of scab they caused. Millard and Burr (*ibid*) considered the deep " pitted " form of scab typical of that caused by *Actinomyces scabies* Thaxt. Güssow, and the raised or " tumulus " form due to a distinct species, *Actinomyces flavus*. De Bruyn (3) is also of the opinion that each type of scab is caused by a different *Actinomyces*. On the other hand, a number of workers believe that environmental factors together with the degree of the severity of attack determines the type of scab which is produced, and Goss (4) claims to have produced common, deep, and raised scab all from a pure culture of *Actinomyces scabies*.

Scab infection frequently starts at the lenticels of the young tuber. The first symptom of disease is the development of minute reddish or brownish spots. These increase in size, and their colour soon becomes dark brown. In the host, the invading organism stimulates the meristem to form elongated cells, and to produce a cork barrier. This cork barrier, however, is seldom perfect, and the organism penetrates below it, and invades the deeper tissue: the subsequent stimulation set up there leads to the formation of another cork layer. This in turn is passed, the stimulus of the meristem resumed, and the development of successive layers of cork in this manner leads to the enlargement of the lesion. Meanwhile, the cells cut off by the cork layers collapse, turn brown, and accumulate in the lesion, giving the scab its characteristic appearance. Jones (9) found the raised type of scab to possess only one cork barrier.

Lutman (12) states, that while infection occurs through stomata and lenticels, it may also occur at any place on the skin where two cells join in very small tubers, 0.5 to 1 cm. diameter. According to Lutman (*ibid*) a scruffiness and browning of the tuber apparently results from a general infection of the periderm and not from isolated penetrations through lenticels.

Object and Plan of the Trials.

Although scab is considered only a very minor trouble by the majority of farmers in this country, there are districts where scabby potatoes are the rule. Some of these districts are in other respects very suitable for the production of seed potatoes, but common scab has been a limiting factor to the development of the seed potato trade in such areas. The main object of the trials was to find out if any variety of potato available in this country possessed sufficient resistance to scab, so that it might be recommended to replace those sorts commonly grown where scab is prevalent.

Plots. The trials were carried out conjointly with the Department of Agriculture. Small semi-permanent plots were established at each of the Department's Agricultural Stations, viz.: Athenry, Co. Galway; Ballyhaise, Co. Cavan; Clonakilty, Co. Cork; and also at the Albert Agricultural College, Glasnevin, Co. Dublin. The

plots were thus situated in localities with different rainfalls. The location of the plots is shown on accompanying map. Each plot was approximately 10 × 16 yards in size. This area was large enough for 18 drills 30 inches apart, and for 18 plants in the drill at 18 inches apart. The same plot was planted with potatoes each year. When sufficient varieties were not forthcoming to plant the entire plot, as occurred in 1944, that part not under trial was cropped with any variety available. This ensured all the plot being under potatoes every year.

Manuring and Treatment. The original intention was to apply farmyard manure at the rate of 15 tons per statute acre, and to supplement this with a dressing of the standard mixture of artificials recommended for potatoes by the Department. This procedure, however, could not always be followed. Owing to the lack of superphosphate and potash during the war period, dressings of one or more of the mineral manures frequently had to be omitted. Occasionally this led to some variation between the manurial treatments at the different stations, but farmyard manure was applied to every plot each year, either at the prescribed dressing, or, where no artificials were available, at the rate of 20 tons per statute acre. The spraying and general treatment of the plots were similar at all stations.

Contaminating Material. In the first year of the trials, parings of badly scabbed tubers were sent out at planting time. These parings were sown over the manure which was placed in the bottom of the drill. At the end of the first season, all potatoes from the different stations affected with *Actinomyces* were kept. These tubers were pared the following spring, the diseased skins thoroughly mixed together and distributed to the various stations, this material being sown in the drill over the manure at planting time. The same procedure was followed with the scabbed potatoes in the second year, the diseased skins being distributed in the third spring of the trials and used as contaminating material. It was hoped in this way to overcome any question of different strains of *Actinomyces* being present at the various stations. It was not considered necessary to send out any diseased material after the third year.

Planting. All seed tubers were assembled at Glasnevin during the dormant season each year, and the requisite quantity forwarded in the following spring to each of the other stations. Although the varieties came from different localities each year, any particular variety planted at each of the four stations originated from the same source. Seed tubers sent out were not visibly affected with scab. The varieties were planted in the same order at all stations, see Tables 2-7.

The dates of planting varied somewhat at the different stations each year. Planting at Athenry and at Glasnevin was carried out during the month of April; in early springs this took place during the first fortnight of the month, and in late seasons towards the end of the third week. At Clonakilty planting in early spring seasons was generally done about one week sooner than at Glasnevin: at Ballyhaise the planting dates on the whole were a week or ten days later each year than at Glasnevin.

Standards and Examination of Tubers. As the amount of scab varies from year to year, being greatest in dry years, some common standard was necessary for comparison each year. The varieties Up-to-Date and Majestic were selected for this purpose. Both these varieties are very susceptible to scab, and both are widely grown, so that fresh supplies of seed were easily obtainable every spring. Two drills of each of these varieties were grown in each plot every year of the trials, the position of the variety being changed each year, see Tables 2-6. In 1946, when supplies of varieties were becoming difficult to procure, two-thirds of the plot at each station were planted with Up-to-Date and Majestic, the remaining drills being planted with Kerr's Pink, Great Scot, and Golden Wonder. The reason for this will be referred to in the discussion.

To reduce the personal factor to a minimum, all examination of tubers was carried out by the writer and two assistants, the same team being employed throughout. At harvest time each year the potatoes were dug and the produce of each drill bagged separately, and then forwarded from the respective station to Glasnevin. Here the tubers were washed, weighed and graded into three groups, namely: Scab Free (i), Slight Scab (ii), and Severe Scab (iii). Slight Scab included tubers with a single spot and those with up to a quarter of their surface scabbed. Severe Scab included all tubers with more than a quarter of their surface affected. Percentages are given to the nearest whole number.

Observations on the Soils at the Four Agricultural Stations.

I am indebted to Dr. T. Walsh, Soil Science Division, Department of Agriculture, Dublin, for the following data regarding the soils at the different stations. The chemical analyses were carried out at the conclusion of the trials.

Athenry, Co. Galway.—The soil here is a medium loam derived from limestone. Crumb structure well developed and free drainage.

Ballyhaise, Co. Cavan.—Soil a medium loam. Silurian derivative. Inferior crumb structure with a tendency towards drainage impediment.

Clonakilty, Co. Cork. Soil a light to medium loam, somewhat gravelly. Silurian derivative. Crumb structure well developed and free drainage.

Glasnevin, Co. Dublin. The soil a stiff clay loam. Derived from Boulder clay. A tendency towards cloddy crumb structure. Drainage fair to poor.

TABLE I.

CHEMICAL ANALYSIS OF SOIL FROM PLOTS AT THE DIFFERENT STATIONS.

	Athenry	Ballyhaise	Clonakilty	Glasnevin
pH	7·9	5·2	5·9	6·9
Nitrate nitrogen	Low+	Low-medium	Low-medium	Low
Ammonia nitrogen	Low	Low	Medium	Medium
Phosphorus ...	Very high	Medium	Medium-high	Very high
Potash ...	Medium-high	Medium-high	Medium-high	Medium-high
Calcium ...	Extra high	Low+	Medium-high	Very high
Magnesium ...	Very high	Low-medium	Medium	Medium
Manganese ...	Trace+	Medium	Trace+	Low
Iron (Ferric) ...	Low+	Medium	Low-medium	Low

NON-INOCULATED PLOT, GLASNEVIN.

In addition to the artificially inoculated plot at Glasnevin, referred to in Tables 2-7, another plot to which no infecting material was added was laid down in the same field at a distance of 100 yards from the first mentioned plot. Varieties planted each year and treatment of the two plots were otherwise similar, so that this second plot was more or less in the nature of a control. Notwithstanding the lack of diseased peelings, many varieties in the non-inoculated plot gave slightly more scabbed tubers than they did in the inoculated plot, as is shown by the following data:—

In 1941, of the 15 varieties tested 9 had more scabbed tubers in the control.
,, 1942, ,, ,, 16 ,, ,, 9 ,, ,, ,, ,, ,, ,, ,,
,, 1943, ,, ,, 16 ,, ,, 5 ,, ,, ,, ,, ,, ,, ,,
,, 1944, ,, ,, 10 ,, ,, 9 ,, ,, ,, ,, ,, ,, ,,
,, 1945, ,, ,, 16 ,, ,, 8 ,, ,, ,, ,, ,, ,, ,,

Throughout the six years the variety Up-to-Date consistently gave rather more scabbed tubers in the non-inoculated plot than in that to which the diseased skins were added and in four of the six years Majestic did the same. The difference in the amount of infection between the two plots was very little (in the neighbourhood of 5 per cent.). These results, however, indicate, that in so far as the soil at Glasnevin is concerned, the addition of scabbed peelings failed to increase the amount of *Actinomyces scabies*. This of course, cannot be said of the plots at the other three stations as there were no corresponding controls.

TABLE 2.

Susceptibility of Potato Varieties to *Actinomyces scabies* at four Agricultural Stations in 1941.

Scab Free (i) — Slight Scab (ii) — Severe Scab (iii)

Variety	Athenry			Ballyhaise			Clonakilty.			Glasnevin.		
	Per cent. by weight.			Per cent. by weight.			Per cent. by weight.			Per cent. by weight.		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Epicure	25	65	10	0	42	58	13	46	41	49	46	5
Arran Crest	4	80	16	0	40	60	17	39	44	46	50	4
Eclipse	45	43	12	3	62	35	51	39	10	76	23	1
Majestic	0	64	36	0	23	77	27	48	25	18	81	1
Arran Pilot	14	80	6	1	58	41	25	58	17	57	43	0
Arran Peak	19	54	27	0	21	79	24	56	20	58	37	5
British Queen	8	66	26	0	43	57	34	49	17	48	52	0
Great Scott	0	52	48	0	24	76	5	46	49	13	81	6
Up-to-Date	5	73	22	0	18	82	17	43	40	18	78	4
Arran Banner	9	62	29	0	24	76	6	53	41	24	73	3
Kerr's Pink	0	42	58	0	29	71	11	43	46	25	69	6
King Edward	17	70	13	0	31	69	18	42	40	54	46	0
Majestic	1	80	19	0	21	79	16	45	39	14	80	6
Dunbar Standard	0	47	53	0	7	93	8	59	33	25	70	5
Arran Victory	4	92	4	0	16	84	20	49	31	19	77	4
Up-to-Date	3	43	54	0	27	73	12	45	43	14	78	8
Gladstone	5	75	20	0	10	90	7	41	52	39	61	0

TABLE 3.

Susceptibility of Potato Varieties to *Actinomyces scabies* at four Agricultural Stations in 1942.

Variety.	Athenry.			Ballyhaise.			Clonakilty.			Glasnevin.		
	Per cent. by weight.			Per cent. by weight.			Per cent. by weight.			Per cent. by weight.		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Sharpe's Express	62	33	5	58	38	4	0	33	67	73	27	0
May Queen	57	29	14	50	46	4	1	21	78	81	19	0
Majestic	11	60	29	30	56	14	0	9	91	51	49	0
Catriona	36	50	14	76	24	0	1	25	74	100	0	0
Duke of York	48	49	3	38	58	4	16	35	49	92	8	0
Ulster Monarch	17	75	8	47	53	0	9	58	33	82	18	0
Up-to-Date	12	73	15	27	64	9	1	29	70	28	70	2
Arran Cairn	9	71	20	27	66	7	0	15	85	44	56	0
Arran Consul	18	67	15	38	55	7	0	10	90	76	24	0
Dunbar Yeoman	9	67	24	37	53	10	0	21	79	67	33	0
Majestic	5	55	40	46	44	10	0	2	98	47	51	2
President	55	33	12	39	53	8	0	18	82	90	10	0
Red Skin	4	41	55	10	45	45	0	15	85	52	46	2
Shamrock	48	37	15	48	45	7	0	18	82	79	21	0
Golden Wonder	67	30	3	58	42	0	0	14	86	100	0	0
Up-to-Date	9	53	38	17	52	31	0	9	91	56	44	0
Champion	20	55	25	37	47	16	2	42	56	89	11	0
Doon Star	27	39	34	9	50	41	35	43	22	85	15	0

TABLE 4.

Susceptibility of Potato Varieties to *Actinomyces scabies* at four Agricultural Stations in 1943.

Variety.	Athenry.			Ballyhaise.			Clonakilty.			Glasnevin.		
	Per cent. by weight.			Per cent. by weight.			Per cent. by weight.			Per cent. by weight.		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Doon Early	10	83	7	21	70	9	14	59	27	38	54	8
Up-to-Date	14	70	16	7	73	20	12	32	56	25	72	3
Doon Erin	17	70	13	42	58	0	7	50	43	72	28	0
Edzell Blue	10	69	21	71	28	1	18	55	27	58	42	0
Ulster Chieftain	3	74	23	29	52	19	70	15	15	58	42	0
Majestic	4	78	18	10	62	28	11	50	39	7	64	29
Irish Chieftain	19	68	13	28	69	3	4	29	67	54	46	0
Di Vernon	11	66	23	73	27	0	58	37	5	72	28	0
Ballydoon	16	68	16	27	69	4	14	43	43	67	33	0
Up-to-Date	1	75	24	11	71	18	4	42	54	37	62	1
Dunbar Rover	9	73	18	27	60	13	3	50	47	32	68	0
Dunbar Cavalier	14	60	26	4	60	36	3	39	58	57	39	4
Field Marshal	3	76	21	5	59	36	0	42	58	31	69	0
Langworthy	6	77	17	25	67	8	7	38	55	58	42	0
Irish Queen	2	56	42	0	44	56	0	44	56	13	79	8
Abundance	7	73	20	9	68	23	5	43	52	38	62	0
Majestic	9	73	18	0	62	38	4	46	50	17	76	7
Spry's Abundance	6	60	34	1	34	65	3	30	67	10	86	4

TABLE 5.

Susceptibility of Potato Varieties to *Actinomyces scabies* at four Agricultural Stations in 1944.

Variety.	Athenry.			Ballyhaise.			Clonakilty.			Glasnevin.		
	Per cent. by weight.			Per cent. by weight.			Per cent. by weight.			Per cent. by weight.		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Up-to-Date	10	80	10	16	66	18	0	7	93	23	74	3
Skerry Champion	17	72	11	60	40	0	0	44	56	68	32	0
Leinster Wonder	8	92	0	31	69	0	0	4	96	12	67	21
Arran Chief	18	82	0	11	81	8	0	33	67	62	37	1
Majestic	5	84	11	18	72	10	0	2	98	16	72	12
Puritan	41	53	6	31	54	15	0	15	85	35	65	0
Arran Comrade	20	70	10	18	76	6	0	7	93	39	61	0
Majestic	14	86	0	16	75	9	0	0	100	13	83	4
Ninetyfold	20	80	0	33	60	7	0	30	70	50	49	1
Ruby Queen	20	80	0	0	100	0	0	0	100	54	46	0
Early Rose	31	69	0	46	54	0	0	9	91	47	53	0
Up-to-Date	35	65	0	19	69	12	0	4	96	26	74	0
	Remaining six drills at each Station planted with Up-to-Date or Kerr's Pink.											

TABLE 6.

Susceptibility of Potato Varieties to *Actinomyces scabies* at three Agricultural Stations in 1945.

Variety.	Athenry.	Ballyhaise.			Clonakilty.			Glasnevin.		
		Per cent. by weight.			Per cent. by weight.			Per cent. by weight.		
		(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Beauty of Hebron	Plot planted with potatoes but badly damaged by cattle during the growing season: crop negligible and results not included.	69	31	0	0	29	71	34	66	0
Early Market		52	48	0	0	20	80	58	42	0
Gardenfiller		58	42	0	0	54	46	54	44	2
Up-to-Date		55	42	3	0	17	83	31	69	0
Muizen		37	61	2	0	16	84	10	86	4
Bishop		50	47	3	0	39	61	36	64	0
Majestic		37	60	3	0	5	95	16	80	4
Skerry		44	56	0	0	27	73	26	74	0
Invincible		16	55	29	0	16	84	31	67	2
Ben Lomond		45	53	2	0	0	100	21	78	1
Ulster Earl		43	57	0	0	6	94	33	67	0
Stormont Dawn		12	72	16	0	2	98	10	87	3
Ulster Cromlech		64	34	2	0	11	89	33	67	0
Up-to-Date		50	45	5	0	17	83	23	77	0
Ulster Commerce		61	36	3	0	0	100	6	93	1
Home Guard		54	41	5	0	14	86	18	81	1
Ally		52	43	5	0	2	98	39	60	1
Majestic		38	60	2	0	3	97	7	87	6

TABLE 7.

Susceptibility of Potato Varieties to *Actinomyces scabies* at four Agricultural Stations in 1946.

Variety.	Athenry.			Ballyhaise.			Clonakilty.			Glasnevin.		
	Per cent. by weight.			Per cent. by weight.			Per cent. by weight.			Per cent. by weight.		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Up-to-Date	6	74	20*	43	51	6	0	45	55	58	42	0
Majestic	3	82	15*	34	52	14	0	32	68	60	39	1
Up-to-Date	7	73	20*	13	66	21	10	27	63	51	49	0
Majestic	0	85	15*	17	43	40	0	28	72	53	46	1
Up-to-Date	0	88	12*	7	80	13	3	38	59	41	59	0
Majestic	10	82	8*	11	72	17	0	43	57	59	41	0
Kerr's Pink	0	68	32*	22	70	8	†8	45	47	40	60	0
Great Scot	7	62	31	6	66	28	0	40	60	48	52	0
Kerr's Pink	7	73	20*	6	82	12	0	23	77	42	57	1
Up-to-Date	4	73	23*	6	66	28	0	24	76	60	40	0
Majestic	25	67	8*	14	59	27	3	30	67	52	47	1
Up-to-Date	3	76	21*	11	56	33	3	28	69	34	66	0
Majestic	16	70	14*	19	56	25	5	30	65	32	68	0
Up-to-Date	33	59	8	7	67	26	0	23	77	54	45	1
Majestic	37	63	0	22	69	9	2	19	79	58	42	0
Great Scot	15	75	10*	14	79	7	†11	48	41	51	49	0
Kerr's Pink	42	58	0	16	65	19	0	46	54	57	43	0
Great Scot	43	50	7	10	7	20	0	26	74	48	52	0

* All these more or less affected by *Spongospora subterranea*. † Golden Wonder.

Discussion.

Scab Types. In these experiments at the different stations, it was found that all types of scab occurred, viz., pitted, shallow, and raised. Typical specimens of badly affected tubers are illustrated in Figs. 1-4 Plate 3. Sunken scab was usually the predominant form present, but to this there were exceptions. Thus, in some years, two or three varieties from a particular station showed more stud or tumulus scab than sunken lesions, although at the other three stations the same varieties were only affected with sunken scab; and in 1944 practically all scab recorded from Clonakilty was of the raised or tumulus type. In addition to the types of scab mentioned, tubers were occasionally found with a general scruffiness, and it was noted that where this occurred, the affected tubers seldom showed any ordinary scab lesions or wart-like outgrowths. The percentage of tubers affected in this manner was very low, but a few were found every year; and in view of Lutman's work (12) such tubers are included as scabbed.

Varietal Reaction. It will be seen from Tables 2-6, that at one or other of the four experimental stations all 65 varieties of potatoes became badly scabbed. The most resistant variety, Di Vernon, gave only 11 per cent of clean tubers, and all varieties showed more than 20 per cent severe scab at one or other of the stations. Four of the least affected, namely Di Vernon, Ulster Chieftain, Edzell Blue, and Doon Early, had between 20 and 30 per cent. severe scab. A second group of 9 varieties in their respective order, viz., Ulster Monarch, Eclipse, Arran Pilot, Doon Star, Doon Erin, Ballydoon, Gardenfiller, Dunbar Rover, and Duke of York, showed more than 30 and less than 50 per cent. severe scab. The remaining 52 varieties developed more than 50 per cent. severe scab at one or other of the four stations, with the percentage of clean tubers frequently nil. It will be noted that the varieties showing less than 50 per cent. severe scab are nearly all earlies or second earlies, the two exceptions being Doon Star and Doon Erin, which are maincrops. There is a tendency for early varieties to escape infection when treated as earlies, but many of them are liable to become badly scabbed when planted late. Epicure provides a good example of an early variety reacting in this way.

It is common knowledge that potato varieties differ greatly in their susceptibility to *Actinomyces scabies*, and there is a general belief that russet varieties are on the whole least likely to scab. Lutman (11) concluded that "thickness of the skin determines the resistance of the tubers to scab." He points out that close-textured lenticels partly buried under the skin surface and filled with small cells are associated with the russet type of potato, and that all russet varieties seem at least moderately resistant. On the other hand, Darling, Leach, and Krantz (2) could get no confirmation that resistance is correlated with a thick or russet skin. In so far as *A. scabies* is concerned, Jones (9) could see no reason why russet-skinned tubers should be resistant, unless their deep set lenticels become suberised at an early stage.

In Ireland the variety Golden Wonder, under ordinary cultivation, scarcely ever shows scab. This variety is a russet, and it has, perhaps, the thickest skin of any

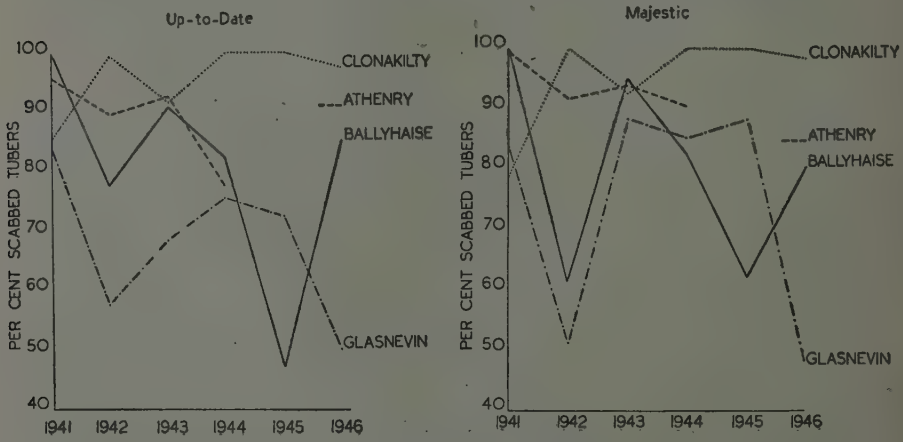
kind grown in Great Britain or Ireland. Nevertheless in these experiments Golden Wonder scabbed 100 per cent. at Clonakilty (86 per cent. severe scab) Table 3. Almost the entire surface of the tubers was covered with scab lesions which had coalesced. A second trial at the same place with another sample of Golden Wonder (supplied from a stock which had never previously been seen to scab) also gave a high percentage of scabbed tubers, (Table 7). In this latter trial practically all the scab on Golden Wonder was of the stud type. At Glasnevin, Golden Wonder was 100 per cent. scab free, and at the other two station moderately affected with slight scab (Table 3).

The result of these experiments fully confirm that of the German workers, Böning and Wallner (1) who found that varietal susceptibility data obtained in one district are not necessarily applicable to other parts of the country.

As regards the association of a russet skin with resistance to scab, it is evident from Table 4 that in the case of Field Marshal (which is considered to be simply a russet Up-to-Date) the russet skin did not confer any resistance whatever on this variety.

Although some varieties occasionally scabbed worse than Up-to-Date or Majestic, both these maintained their reputation for susceptibility to scab throughout. From Tables 2-6, it is seen that these two varieties were on the whole amongst the most susceptible every year at all stations. Even at Glasnevin, (where the least development of scab occurred) the susceptibility of Up-to-Date and Majestic is shown by the relatively small percentage of clean tubers every season.

Lack of Rotation and Scab Development. The use of farmyard manure is believed to favour the development of *Actinomyces scabies*, and scabbed peelings, added to the drills at planting time, would presumably increase the amount of soil infection. In spite of these two additional factors, however, an examination of the behaviour of Up-to-Date and Majestic over the six year period does not lend



much support to the oft quoted statement " that continual cropping with potatoes increases the amount of scab." In the accompanying graphs the percentage of scabbed tubers by weight (average of two drills 1941-45 and of six drills in 1946) is plotted against the year for each station. In the case of Up-to-Date more scab occurred in the first year at three of the stations than in any subsequent year; but at Clonakilty less scab was found the first season than occurred afterwards. A similar increase in scab on Majestic occurred after the first year at Clonakilty. The graph for Majestic shows that at Glasnevin there was a slight increase in scab in three years above what occurred the first year, but a very big drop in the amount of disease took place in the second and sixth years. At Athenry and Ballyhaise scab on Majestic ran the same course as it did on Up-to-Date; more infection occurring the first season than in any of the later years.

The first year (1941) was by far the driest of any of the six years, see Table 8. The growing season of 1942, extending from April to September inclusive, was not only the wettest, but had the least sunshine for any similar period during the previous decade. Sanford (15) states that the optimum temperature for growth of *Actinomyces scabies* is around 27°C., and that a plentiful supply of oxygen is necessary for its development. There is little doubt, therefore, that the high rainfall and consequent reduction in the amount of oxygen in the heavier soils at Athenry, Ballyhaise, and Glasnevin, was mainly responsible for the considerable drop in infection in 1942 at these stations. A similar effect would not be expected in a light gravelly soil where waterlogging would be unlikely to occur. In confirmation of this, it was found that there was actually much more scab at Clonakilty in 1942 than in the previous year. Indeed, although the soil at this station is acid, a consistently higher degree of scab infection occurred here after the first year than at any other station. These results confirm the view that an adequate supply of oxygen is one of the most important factors in scab development. Incidentally, the Clonakilty plot is the only one of which it might be said that scab increased owing to continual cropping with potatoes.

Observations on Other Diseases. In the first year of the trials (1941) a few spots of Powdery Scab (*Spongospora subterranea*) were found on some of the tubers received from Athenry, Co. Galway. The following year (1942) was one of the wettest in Ireland for a decade, and Powdery Scab was more evident on potatoes from the same station, three varieties, viz., Champion, Golden Wonder, and Red Skin, being affected with the canker form of the disease. From then onwards Powdery Scab was more or less prevalent on the potatoes grown at Athenry, and in 1946, another wet year, practically every variety was attacked by *Spongospora subterranea.* Accompanying this development of Powdery Scab there was a reduction in the amount of Common Scab, and not infrequently tubers were attacked by *Spongospora subterranea* to the entire exclusion of *Actinomyces Scabies*, Fig. 5, Plate 4.

In addition to this partial replacement of Common Scab by Powdery Scab at Athenry, there was also a virulent development of Black Scurf (*Corticium Solani*). This disease was exceptionally severe in 1946, visual infection of the tubers varying in intensity from a few small black specks to large lumps or, more often, to an almost entire incrustation of the tuber by a mass of sclerotia, Figs. 6, 7 and 8, Plate 4. Even where tubers seemed to be devoid of sclerotia, a microscopical examination of the eyes showed that these contained a weft of hyphae of *Rhizoctonia*, Fig. 9, Plate 4.

Apparently a somewhat similar change took place in the micro-flora of the soil in the plot at Ballyhaise, Co. Cavan. Black Scurf (*Corticium Solani*) and Silver Scurf (*Spondylocladium atrovirens*) developing here and increasing in amount from year to year, until in the last two years of the trials nearly every tuber was affected by one or both diseases.

Some development of *Corticium Solani* also occurred in the plots at Clonakilty and Glasnevin, Black Scurf being rather prevalent on the tubers in 1945-46. The degree of tuber infection, however, was never anything like what occurred at the other two stations.

In America, Goss and Afanasiev (5) working with crops under irrigation found that *Rhizoctonia* (*C. Solani*) was most severe with continuous culture of potatoes and in short rotations. The same workers record that the application of barnyard manure in the short rotations decreased the percentage of infected tubers.

Owing to the early appearance and steady increase in the amount of Powdery Scab in the Athenry plot, a close watch for this disease was kept on the produce from the other three stations. Finally, in 1946, several drills of Kerr's Pink and Great Scot were planted in every plot. It was known from past experience that both these varieties are very susceptible to *Spongospora subterranea*. Traces of Powdery Scab were found on some of the tubers from the plot at Ballyhaise in 1946, but this disease was not found on potatoes from either Clonakilty or Glasnevin. Therefore, although the development of Powdery Scab at Athenry constituted more or less of a nuisance in the examination of the tubers from this station, its occurrence does not invalidate the results as a whole.

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Summary.

During the years 1941-1946 inclusive, a number of potato varieties were tested for their susceptibility to Common Scab, *Actinomyces scabies* Thaxt. Güssow.

These trials were carried out in semi-permanent plots at four Agricultural Stations situated in various parts of Ireland, and hence in localities with different rainfalls. The soils differed in origin, but the fertility status of the four soils was fairly uniform. Their pH range was 5.2, 5.9, 6.9, and 7.9.

All 65 varieties of potatoes tested scabbed badly at one or other of the four stations; the least affected being scabbed to the extent of 89 per cent by weight, and with more than 20 per cent severe scab, *i.e.* more than one-quarter of the tuber surface scabbed.

The first year of the trials was the driest of the six-year period, and was the most favourable for scab.

There is little evidence from three of the stations of any increase of scab due to continual cropping with potatoes.

Want of rotation, however, definitely increased the amount of Black Scurf (*Corticium Solani*) at all stations, of Powdery Scab (*Spongospora subterranea*) at one station, and of Silver Scurf (*Spondylocladium atrovirens*) at another.

Explanation of Plates.

Plate 3.

Fig. 1. Pitted form of Common Scab, *Actinomyces scabies* Thaxt. Güssow.

Fig. 2. Raised or stud type of Common Scab of Potatoes.

Fig. 3. Mixed shallow and stud types of scab on same tuber.

Fig. 4. Tuber with its entire surface affected with shallow scab.

Plate 4.

Fig. 5. Tuber from the Athenry plot, 1946, showing canker form of Powdery Scab, *Spongospora subterranea* Wallr.

Fig. 6. Tuber badly incrusted with sclerotial mass of the Black Scurf fungus, *Corticium Solani* (Prill. & Delacr.) Bourd. & Galz.

Fig. 7. Tuber showing normal sclerotia of *Corticium Solani*.

Fig. 8. Tuber with giant sclerotium of *Corticium Solani*.

Fig. 9. Eye from tuber devoid of visual infection enlarged to show weft of hyphae of *Corticium Solani* present. X 14.

TABLE 8.

Number of days on which precipitation occurred at the four Agricultural Stations and rainfall in inches for months April-September inclusive, 1941-46.

Month	Athenry, Co. Galway		Ballyhaise, Co. Cavan		Clonakilty, Co. Cork		Glasnevin, Co. Dublin	
	No. of days	Rainfall inches	No. of days	Rainfall inches	No. of days	Rainfall inches	No. of days	Rainfall inches
April – 1941	8	1·50	9	1·61	16	1·50	15	3·07
May ,,	8	1·79	15	2·01	15	2·20	12	2·24
June ,,	8	1·13	14	1·04	22	1·44	11	0·77
July ,,	10	2·86	20	2·10	14	3·00	16	1·67
August ,,	15	3·76	23	3·67	25	3·67	24	2·50
September ,,	11	1·78	8	1·05	11	0·95	12	0·72
Totals ...	60	12·82	89	11·48	103	12·76	90	10·97
April – 1942	8	2·29	10	2·08	16	1·95	13	1·12
May ,,	16	4·66	15	4·62	21	4·75	18	4·20
June ,,	3	0·25	4	0·12	4	0·51	4	0·12
July ,,	23	4·54	19	3·51	16	2·69	19	2·14
August ,,	20	4·24	21	4·95	17	4·36	22	3·76
September ,,	17	5·10	23	4·83	19	2·92	18	4·48
Totals ...	87	21·08	92	20·11	93	17·18	94	15·82
April – 1943	9	1·22	11	1·55	9	2·01	16	1·07
May ,,	15	3·47	19	3·16	16	4·77	16	4·10
June ,,	18	3·93	21	3·65	18	3·03	17	2·10

September ,,	26	2·95	21	2·72	20	3·33	24	2·57
Totals ...	108	20·81	111	20·26	100	19·38	109	13·95
April – 1944	10	1·82	8	2·11	13	3·26	14	1·69
May ,,	11	3·23	14	2·15	9	0·98	10	0·92
June ,,	17	3·01	18	2·38	12	1·12	16	1·46
July ,,	23	4·50	22	3·86	20	4·22	20	2·37
August ,,	21	3·41	15	3·51	13	1·92	16	2·61
September ,,	17	4·15	19	4·31	18	4·98	18	5·56
Totals ...	99	20·12	96	18·32	85	16·48	94	14·61
April – 1945	18	1·66	12	1·44	21	1·37	12	1·49
May ,,	24	3·69	25	3·28	27	3·00	18	1·80
June ,,	23	5·25	27	3·69	17	2·60	21	3·37
July ,,	25	5·82	17	4·71	21	3·65	16	3·05
August ,,	19	2·83	14	2·62	20	2·10	12	0·87
September ,,	17	4·20	17	2·89	17	2·48	18	2·27
Totals ...	126	23·45	112	18·63	123	15·20	97	12·85
April – 1946	16	2·36	13	0·92	12	1·03	16	1·31
May ,,	15	2·03	11	1·51	16	3·00	13	2·09
June ,,	23	4·12	27	2·44	24	4·03	24	3·48
July ,,	22	3·87	27	3·42	18	2·34	18	2·60
August ,,	28	4·82	29	4·81	22	5·06	24	5·36
September ,,	26	5·59	28	6·09	26	4·63	25	5·97
Totals ...	130	22·79	135	19·19	118	20·09	120	20·81

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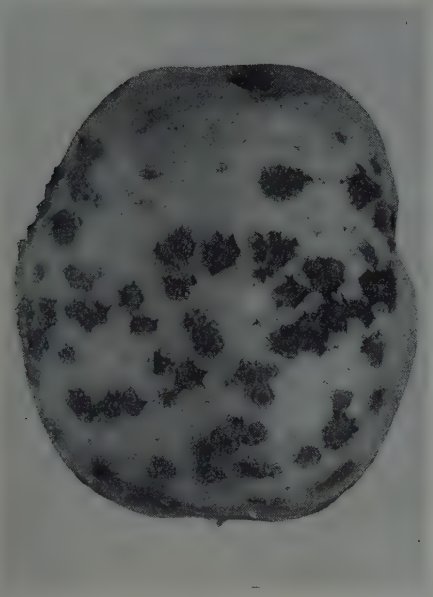

Fig. 1

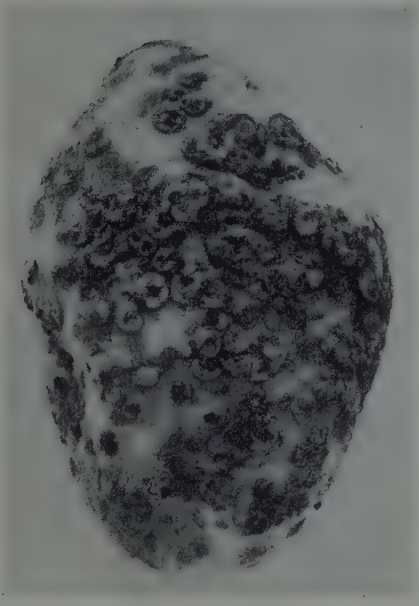

Fig. 2

Fig. 3

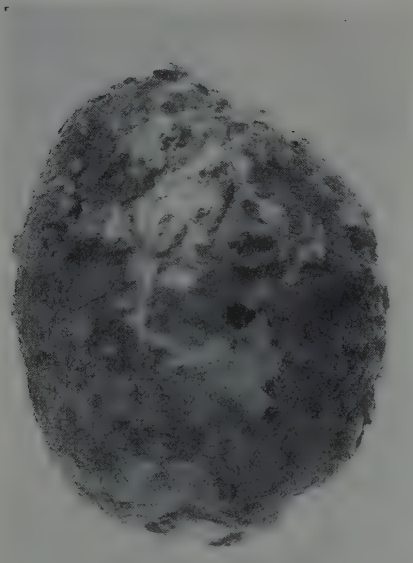

Fig. 4

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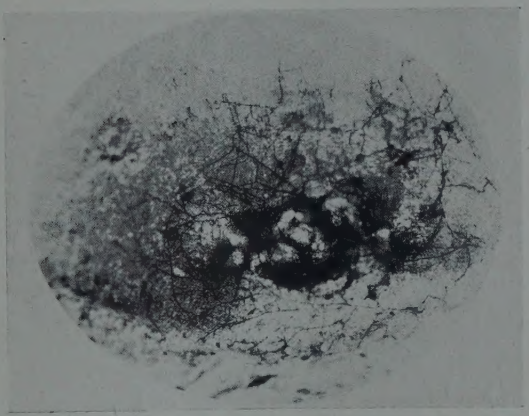

Fig. 9

Fig. 7

Fig. 8